Industrial DC/DC Buck Converters
BD9x Series

White Paper

The BD9x series consists of 10 DC-DC buck converters with built-in MOSFETs. Both synchronous and diode rectifier types are offered in a wide range of input voltages (2.7V to 76V), making them ideal for a broad variety of industrial applications. All models feature an expanded junction temperature range up to +150ºC. In addition, multiple protection circuits are built in, including over voltage/current protection, thermal shutdown, short-circuit protection, and under-voltage lockout, ensuring superior reliability. ROHM also provides comprehensive support and stable, long-term supply (10-15 years) demanded by the industrial market.

Introduction

To achieve the most efficient regulator design, several factors must be considered with respect to power management architecture and technology. Understanding application requirements such as output regulation, operating voltage, temperature range, transient response, system footprint, and component budget are important evaluation points that should be taken in the initial design steps. This paper is geared towards helping the designer select the buck converter within ROHM's BD9x series best suited for their particular industrial application needs.

The BD9x series features high-speed transient response and allows for easy phase compensation. Synchronous types are offered that include both high-side and low-side MOSFETs, along with an diode rectifier type with high-side MOSFET.

Figure 1 is a generic block diagram showing a synchronous buck converter with control circuitry together with over voltage/current, short-circuit, thermal shutdown, and under-voltage lockout protection blocks, both high-side and low-side MOSFETs, and a soft start sequencer.

The series covers a wide input range, varying from a minimum of 2.7 to 12V up to 5.5 to 76V max. (Table 1). Of the 10 models in the lineup, 9 are synchronous converters, with 8 utilizing current mode control and 1 adopting constant on-time control. The remaining unit is a diode rectifier type featuring current mode control. The switching frequency ranges from 50kHz to 2MHz.

Basics

Switching regulators are preferred in applications that place an emphasis on efficiency. Buck regulators are a kind of switching regulator that operates using two different states to convert a higher input voltage to a lower output voltage.

Figure 2 shows the state in which the switch 'S' is closed and energy is supplied to the load while the inductor is charging. Figure 3 depicts the state where the switch 'S' is open and the inductor discharges, continuing to supply energy to the load.

Figures 4 and 5 are circuit diagrams of the two types of buck regulators, diode rectifier and synchronous, respectively. In the diode rectifier type, the diode is reverse biased when the switch 'S1' is closed and forward biased when the switch 'S1' is open due to collapsing of the inductor's magnetic field (which occurs without any clock reference). The diode's forward voltage constitutes a significant portion of the loss. As a result, synchronous types that replace the diode with a low-side MOSFET are more efficient.

Synchronous rectifier regulators involve a more complex control circuit to ensure that the high-side and low-side MOSFETs are not turned on simultaneously. The control logic makes this topology synchronous.

The duty cycle of a buck regulator is defined as D, which can be represented by

where

t_{on} = on time of the high-side MOSFET

$$D = \frac{t_{on}}{t_{on} + t_{off}}$$

t_{off} = off time of the high-side MOSFET

The duty cycle is proportional to the required output voltage and load. The control logic can be either current or voltage mode control. Providing compensation for voltage mode control, however, is relatively more complex.

Perhaps the most significant challenge addressed by integrated solutions is board layout, including power stage configuration, grounding schemes, capacitor placement, and the proximity of power and analog traces. Incorporating functional blocks such as FET power staging and current sensing reduces the number of external discrete components. This decreases routing complexity and saves valuable board space along with BOM (Bill of Materials).

Challenges

High operating voltages and temperatures are typical conditions faced by buck converters used in industrial applications. However, it is important to balance the need for fast transient response and high efficiency with demands for smaller package size and footprint along with lower costs. Tables 1 and 2 lists the key parameters that will enable designers to select the ideal solution for their particular application.

Applications

The BD9x series covers a wide range of input voltages, providing support for applications that include factory automation, PV (Solar) inverters, communication infrastructure, smart meters, and battery management systems.

In addition, safety features such as over current protection, thermal shutdown, short circuit protection, and under voltage lockout as well as a soft start function to protect against inrush current are built in, delivering the high reliability demanded by the industrial market.

Conclusion

Tables 1 and 2 list the entire BD9x lineup along with key characteristics. The ‘LB’ at the end of the part number indicates that the model is industrial grade, meaning its spec parameters conform to industrial requirements. ROHM also guarantees supply and support for these products for ten to fifteen years.

The 10-model lineup consists of 9 synchronous and 1 diode rectifier converters. Figures 4 and 5 show the circuits for the diode rectifier and synchronous types, respectively. The diode used at the low-side of diode rectifier regulators is a major source of loss due to its forward voltage, resulting in significantly lower efficiency compared to synchronous buck converters that adopt a MOSFET at the low-side.

It should be noted that the diode losses of diode rectifier converters are considered system loss and not a part of the converters themselves, since the diode is an external component. This is an important factor when looking at comparative data (efficiency vs output current) between synchronous and diode rectifier types. As a result, while the losses are still a part of the system, the BOM (Bill of Materials) for diode rectifier converters will also include the extra cost of the diode.

Table 1 lists the input voltage ranges of the BD9X series, along with the topology (synchronous/diode rectifier), control mode, RDS(on) of the both the high-side and low-side MOSFETs, output current, and switching frequency.

Table 2 includes key parameters such as standby current, efficiency, protection circuits, soft start sequence, and package type. Both the VQFN016V3030 and HTSOP-8 packages are high heat dissipation designs.

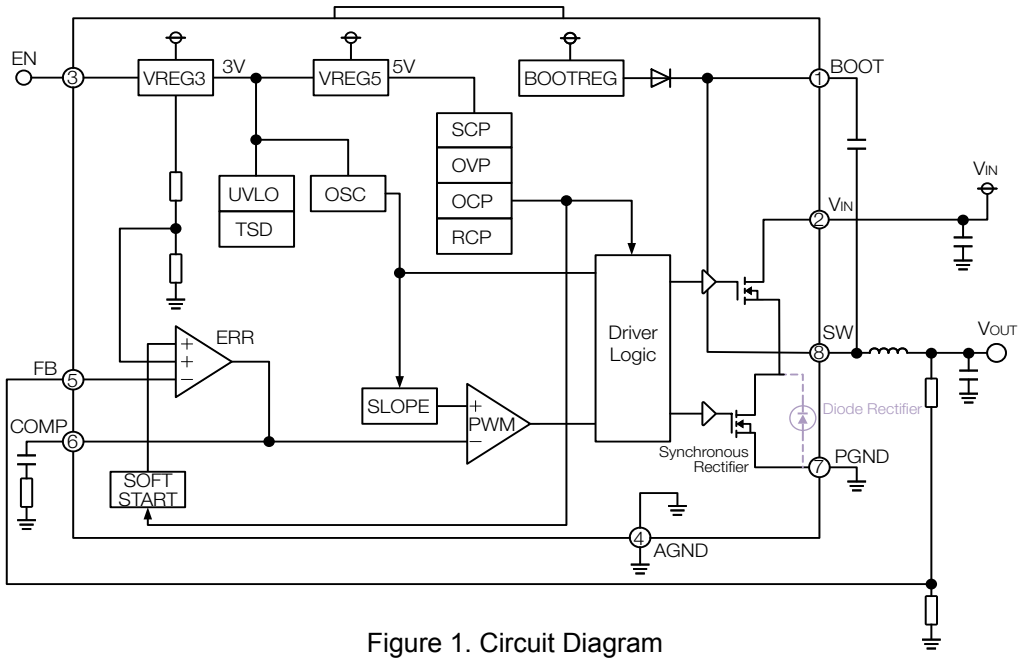

Figure 1. Circuit Diagram

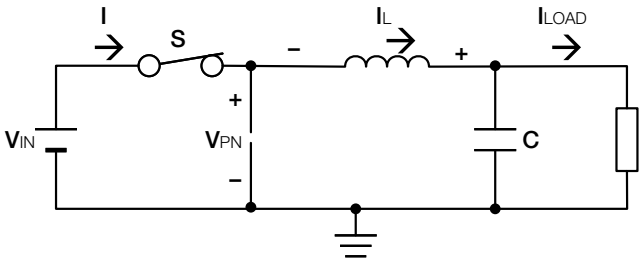

Figure 2. Inductor Charging

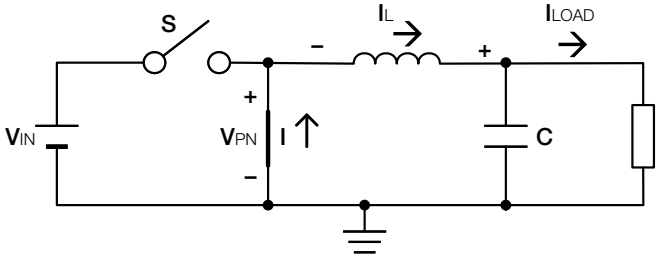

Figure 3. Inductor Discharging

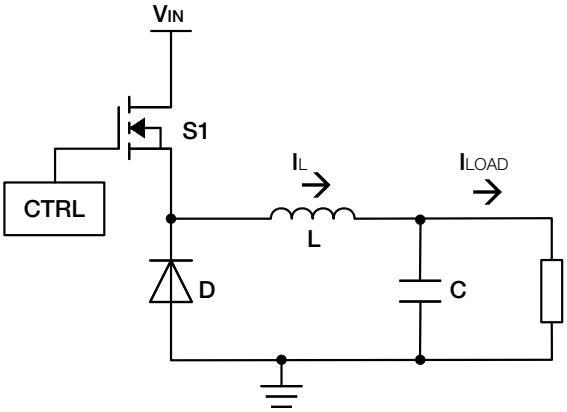

Figure 4. Diode Rectifier Regulator

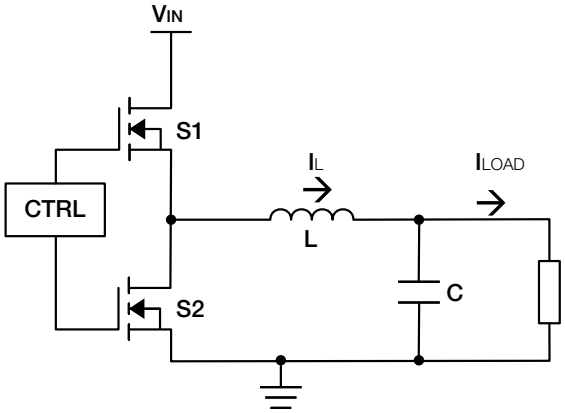

Figure 5. Synchronous Rectifier Regulator

Part No.	Spice Model	V_{IN} Range (V)	Synchronous	Control Mode	RDS ON (mΩ)		Output Current (A)	Output Voltage (V)	Sw Freq (kHz)
					HS	LS			
BD9A101MUV-LB	Available	2.7 - 5.5	Yes	Current	60	60	1	0.8 - 0.7xV_{IN}	1000
BD9A301MUV-LB	Available	2.7 - 5.5	Yes	Current	60	60	3	0.8 - 0.7xV_{IN}	1000
BD9B301MUV-LB	Available	2.7 - 5.5	Yes	Constant On-time	35	35	3	0.8 - 0.8xV_{IN}	2000/1000
BD9C301FJ-LB	Available	4.5 - 18	Yes	Current	65	35	3	0.8 - 0.7xV_{IN}	500
BD9E100FJ-LB	Available	7 - 36	Yes	Current	300	300	1	1 - 0.7xV_{IN}	1000
BD9E101FJ-LB	Available	7 - 36	Yes	Current	300	300	1	1 - 0.7xV_{IN}	570
BD9E300EFJ-LB	Available	7 - 36	Yes	Current	170	140	2.5	1 - 0.7xV_{IN}	1000
BD9E301EFJ-LB	Available	7 - 36	Yes	Current	170	140	2.5	1 - 0.7xV_{IN}	570
BD9E303EFJ-LB	Available	7 - 36	Yes	Current	90	80	3	1 - 0.8xV_{IN}	300
BD9G341AEFJ-LB	Available	12 - 76	No	Current	150	–	3	1 - V_{CC}*	50 - 750

Table 1. BD9x Series Specifications

*Please refer to datasheet.

Part No.	Eval Board	Standby Current (µA)	Efficiency (%)	OCP	SCP	TSD	UVLO	Soft Start	Package
BD9A101MUV-LB	Available	0	>90	✓	✓	✓	✓	Adjustable	VQFN016V3030
BD9A301MUV-LB	Available	0	>90	✓	✓	✓	✓	Adjustable	VQFN016V3030
BD9B301MUV-LB	Available	0	>90	✓	✓	✓	✓	Adjustable	VQFN016V3030
BD9C301FJ-LB	Available	1	>90	✓	✓	✓	✓	Fixed	SOP-J8
BD9E100FJ-LB	Available	0	>90	✓	✓	✓	✓	Fixed	SOP-J8
BD9E101FJ-LB	Available	0	>90	✓	✓	✓	✓	Fixed	SOP-J8
BD9E300EFJ-LB	Available	0	>90	✓	✓	✓	✓	Fixed	HTSOP-J8
BD9E301EFJ-LB	Available	0	>90	✓	✓	✓	✓	Fixed	HTSOP-J8
BD9E303EFJ-LB	Available	0	>90	✓	✓	✓	✓	Fixed	HTSOP-J8
BD9G341AEFJ-LB	Available	0	>90	✓	–	✓	✓	Fixed	HTSOP-J8

Table 2. BD9x Series Key Parameters

References

1) 2.7V to 5.5V Input 1.0A Single Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9A101MUV-LB

2) 2.7V to 5.5V Input 3.0A Single Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9A301MUV-LB

3) 2.7V to 5.5V Input 3.0A Single Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9B301MUV-LB

4) 4.5V to 18V Input 3.0A 1ch Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9C301FJ-LB

5) 7.0V to 36V Input 1.0 A Single Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9E100FJ-LB(E2)

6) 7.0V to 36V Input 1.0 A Single Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9E100FJ-LB(H2)

7) 7.0V to 36V Input 1.0 A Single Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9E101FJ-LB(E2)

8) 7.0V to 36V Input 1.0 A Single Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9E101FJ-LB(H2)

9) 7.0V to 36V Input 2.5A Single Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9E300EFJ-LB(E2)

10) 7.0V to 36V Input 2.5A Single Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9E300EFJ-LB(H2)

11) 7.0V to 36V Input 2.5A Single Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9E301EFJ-LB(E2)

12) 7.0V to 36V Input 2.5A Single Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9E301EFJ-LB(H2)

13) 7.0V to 36V Input 3.0A Single Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9E303EFJ-LB(E2)

14) 7.0V to 36V Input 3.0A Single Synchronous Buck DC/DC Converter with Integrated MOSFETs - BD9E303EFJ-LB(H2)

15) 1ch Buck Converter with Integrated MOSFETs - BD9G341AEFJ-LB

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